Appendix C: Ground Validation Data Processing System

The TRMM Office has completed and released version 2.5.1 of the TRMM Ground Validation Data Processing System (GVDPS). This system was delivered to the TRMM Science Data and Information System (TSDIS) on July 21, 1995. This release contains scientific algorithms based on the results of the Algorithm Intercomparison Workshop (AIW) held in Seattle, Washington, December 1994, and subsequently evaluated and approved by the TRMM Ground Validation Team at a GSFC meeting in February 1995. The software framework and GV data flow is outlined in figure C1.

The GVDPS consists of the several different software packages:

1) TRMM Office Radar Software Library (RSL)
2) NCAR Graphics
3) NCAR Sprint
4) University of Washington Convective/Stratiform Classification
5) Hebrew University of Jerusalem Rain Estimation Algorithm
6) University of Iowa Rain Estimation Algorithm

Sections C.1-C.6 provide some essential details on each of the above software packages.

C.1 TRMM Office Radar Software Library

This library is an object oriented programming environment to aid application development of radar processing algorithms. The quality control program (1C-51) is one such application that utilizes the RSL. RSL makes use of format specific libraries to read the data; input formats include WSR-88D, UF, Lassen, SIGMET, TOGA, McGill, and Kwajalein.

The main benefit of using the RSL is that only one data structure is used to hold the radar data. Also, all applications that utilize RSL data structures are inherently portable and are radar format independent. Some of the RSL data structures are: Radar, Volume, Sweep, Ray, Cappi, Carpi, Cube, Column, Vertical_structure, and Histogram. There are approximately 200 user-callable functions that manipulate these data structures.

RSL version 0.38 was delivered as part of GTS version 2.5.1. This library is fully documented via the World Wide Web at

http://trmm.gsfc.nasa.gov/trmm_office/software/radar/index.html

This library is also available to TRMM scientists via anonymous ftp at

ftp://trmm.gsfc.nasa.gov/pub/software.

Figure C1. TRMM GV data flow and framework for operational software development.

RSL version 0.38 requires additional libraries when linking an application. These are: WSR-88D-v1.14.tgz, Lassen-v1.1.tgz, libtg-v1.1.tgz, libnsig-v1.3.tgz, McGill-v1.1.tgz, pbmplus.tgz (optional). These files are in the anonymous ftp directory, pub/software, on trmm.gsfc.nasa.gov.

C.2 NCAR Graphics

The NCAR graphics package is used by the NCAR Sprint software. The TO is working with NCAR to provide cross-platform execution of these software. The TRMM Office is maintaining a version of NCAR graphics that is known to work on HP and SGI systems. That version is 1.0. Version 1.0 of the NCAR graphics package is available via anonymous ftp to trmm.gsfc.nasa.gov in pub/software/ncar_graphics-v1.0.tgz.

C.3 NCAR Sprint

The NCAR Sprint package is used to interpolate the 3-dimensional reflectivity into a 2 km x 2km Cartesian grid (horizontal). This software is also used to produce the level 2A-56 (three-dimensional reflectivity) at 1.5 km vertical resolution. Version 1.1 of the NCAR Sprint package was delivered with GTS version 2.5.1. It is available via anonymous ftp to trmm.gsfc.nasa.gov in pub/software/ncar_sprint-v1.1.tgz.

C.4 University of Washington Convective/Stratiform Classification Algorithm:

The University of Washington is responsible for producing the algorithm and programs for level 2A-54 (stratiform/convective maps). This software requires NCAR graphics and NCAR Sprint for its execution. The source code for the 2A-54 package is contained within GTS 2.5.1.

Consult the following references for more information:

Steiner, M., R. A. Houze, Jr., and S. E. Yuter, 1995: Climatological characterization of three-dimensional storm structure from operational radar and rain gauge data. *J. Appl. Meteor.*, **34**, 1978-2007.

Yuter, S. E., and R. A. Houze, Jr., 1995a: Three-dimensional kinematic and microphysical evolution of Florida cumulonimbus. Part I: Spatial distribution of updrafts, downdrafts, and precipitation. *Mon. Wea. Rev.*, **123**, 1921-1940.

Yuter, S. E., and R. A. Houze, Jr., 1995b: Three-dimensional kinematic and microphysical evolution of Florida cumulonimbus. Part II: Frequency distributions of vertical velocity, reflectivity, and differential reflectivity. *Mon. Wea. Rev.*, **123**, 1941-1963.

Yuter, S. E., and R. A. Houze, Jr., 1995c: Three-dimensional kinematic and microphysical evolution of Florida cumulonimbus. Part III: Vertical mass transport, mass divergence, and synthesis. *Mon. Wea. Rev.*, **123**, 1921-1940.

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C.5 Hebrew University of Jerusalem Rain Estimation Algorithm:

Presently, the Hebrew University of Jerusalem provides the algorithm for converting the radar reflectivity into rain rate maps. This methodology uses the so-called Window Probability Matching Method (WPMM). The product generated is 2A-53. However, within GTS, the package is labeled 2A-53-d. It is labeled this way to distinguish it from the University of Iowa algorithm which also generates a 2A-53 product. The source code for 2A-53-d is completely contained within GTS 2.5.1 and does not require any additional libraries or packages for its execution.

Consult the following references for more information:

Rosenfeld, D., E. Amitai, and D. B. Wolff, 1995: Classification of rain regimes by the 3-dimensional properties of reflectivity fields. The *Journal of Applied Meteorology*, **34**, 198-211.

Rosenfeld, D., E. Amitai, and D. B. Wolff: Improved accuracy of radar WPMM estimated rainfall upon application of objective classification criteria. The *Journal of Applied Meteorology*, **34**, 212-223.

Rosenfeld, D., D. B. Wolff, and E. Amitai: The window probability matching method for rainfall measurements with radar. The *Journal of Applied Meteorology*, **33**, 683-693.

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C.6 University of Iowa Rain Estimation Algorithm:

The University of Iowa, with cooperating institutions, is also providing a rain estimation algorithm for GV. This methodology utilizes a vertically integrated liquid water technique with a range correction parameterization and a global optimization for parameter estimation to derive a surface rainfall estimates, i. e., product 2A-53. The package is designated 2A-53-a within GTS to distinguish it from the Hebrew University algorithm 2A-53-d, above. An additional library, which can be found via anonymous ftp to trmm.gsfc.nasa.gov in pub/software/uiowa_distrib-v2.0.tgz, is used for converting input UF files to RLE (uf2rle). This conversion is a required step prior to executing 2A-53-a. Version 2.0 of this additional library was delivered with GTS version 2.5.1.

Consult the following references for more information:

Ciach, G.J., W. F. Krajewski, E. N. Anagnostou, J. R. McCollum, M. L. Baeck, J. A. Smith, and A. Kruger, 1995: Radar rainfall estimation for ground validation studies of the Tropical Rainfall Measuring Mission. Submitted to *Journal of Applied Meteorology*.

Kruger, A. and W. F. Krajewski, 1995: Efficient storage of weather radar data. Submitted to *Software and Experience*.

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